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AN UNDESCRIBED TIMBER DECAY OF HEMLOCK

ERDMAN WEST

For several years, dead hemlock timber in the vicinity of State College, Pennsylvania, has been destroyed by a peculiar rot which seems to be quite constantly associated with sporophores of the fungus *Polyporus tsugae* (Murrill) Overholts. An investigation of the problem was undertaken at the suggestion of Dr. L. O. Overholts and a preliminary report of the situation prepared but not published. Soon after assuming his duties in New Jersey, the writer noticed a group of hemlocks along the Raritan River near New Brunswick, N. J. An excursion to these showed a large number of them dead or dying from the effects of the root rot fungus *Polyporus schweinitzii.* Some of the trees bore sporophores of the sap rot *Polyporus abietinus,* but most of the trees that had died recently, bore sporophores of *Polyporus tsugae,* sometimes in great abundance. Further investigation showed present in these standing trunks the same rot that had been studied in stumps and prostrate trunks of hemlock near State College. This abundant material has made further observations possible.

Polyporus tsugae (Murrill) Overholts has been reported on pine and hemlock for a number of years but the decay caused by it has never been described. The sporophore was first described by Dr. W. A. Murrill under the present specific name. He placed it in the section *Fomiteae* under the name *Ganoderma tsugae* along with several other species of *Ganoderma.* It is, however, an annual plant and the entire genus as limited by Dr. Murrill more properly belongs in the section *Polyporeae* instead of *Fomiteae.* This point will be given further consideration later. The species has also been referred to the genus *Polyporus* by another writer. The species is very closely related to *Polyporus lucidus* and *P. curtisii.*

Mr. C. G. Lloyd has repeatedly stated in his writings that *P. tsugae* is *not* a good species but only the coniferous wood form of *P. lucidus.* A careful examination, however, shows differences[1] that are sufficient to warrant its being retained as a separate species. First, the context in *P. lucidus* and *P. curtisii* is made up of two layers, the upper one quite whitish and the lower having brown hyphae running all through it, so that to the naked eye it appears brown; in *P. tsugae* on the other hand, the context is never duplex and does not have the brown hyphae, so that the context is light and concolorous from crust to tubes. The difference is very apparent when the pilei are cut vertically and compared. The red varnishing of the pileus is also very characteristic. In *P. lucidus* and especially in *P. curtisii* the red color fades into yellowish brown in spots in almost every specimen, such spots being of a dull color. In *P. tsugae* the pileus is of a dark red or mahogany color all over, with a bright glossy surface. This distinction holds good even in old herbarium specimens if mature when collected. Under the microscope, the type of the hyphae is a distinguishing character. In *P. lucidus* and *P. curtisii* the hyphae are rather slender, being about 4–10 microns in diameter on the average. The hyphae in these two species are not very abundantly branched though they cannot be said to be unbranched by any means. In *P. tsugae* there are slender hyphae but they are always abundantly branched. Besides there are numerous short thick hyphal elements that may be as high as 15 microns in diameter and of very various lengths. These have many small branchlets coming off at various points with many of these lateral hyphae branching several times and terminating abruptly near by. This branching is very conspicuous under high power of the microscope where hardly a hypha will cross the field without branching at least once, while in the other two species, unbranched hyphae crossing the field of vision were relatively frequent. The host may also serve as a guide to the species since *P. lucidus* and *P. curtisii* are, as far as the writer could find, always found on hardwoods, while *P. tsugae* is confined to coniferous wood, especially hemlock.

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[1] Ann. Mo. Bot. Gard., 2, 1915. Comp. Studies Polyporaceae. Overholts.

As mentioned above, these three species have usually been grouped as a part of the genus *Polyporus,* or if given specific rank, placed in the section with *Fomes* as an exception to the perennial character. There is perhaps sufficient reason for giving this group specific rank, for the red varnished pileus, and the truncate, apparently echinulate spores are definite and fixed characters. The spores are especially exceptional. They appear to be echinulate, but closer examination shows, as Professor Atkinson pointed out, that the roughening is a sculpturing of the inner side of the spore-wall and not the outer as in the first impression. The species may be dscribed as follows:

POLYPORUS TSUGAE (Murrill) OVERHOLTS[2]

Pileus reniform or flabelliform, short stipitate when attached to trunks or stumps above ground level, longer stipitate when attached to roots, 5–15 × 6–20 × 1–4 cm., with a mahogany colored or almost black, shining encrusted surface, glabrous, sulcate; context white or nearly so throughout, .5–2 cm. thick; tubes .5–1 cm. long, mouths white or brown, averaging 4–6 per mm.; stem lateral with color and context as in pileus, 3–15 cm. long, 1–3 cm. thick; spores ovoid with a truncate base, apparently echinulate, light-brown, 9–11 × 6–7 μ; hyphae very irregular and much branched up to 15 μ in diameter.

On standing or prostrate trunks, stumps, or exposed or nearly exposed roots of hemlock, *Tsuga canadensis,* probably with a range of its hosts. Occasionally on pine.

It has been reported from Vermont, New Hampshire, Massachusetts, New York, New Jersey, Pennsylvania, Ohio, West Virginia, and North Carolina.

The fungus is at first a sap-rot but it eventually destroys the heart-wood also. Near New Brunswick, a partly uprooted and leaning trunk 14 inches in diameter was entirely destroyed by this rot. Few stumps or dead trunks escape its attacks when it is present in a locality and since it is quite rapid in its work, it is a potential source of danger to stored hemlock lumber.

When first attacked, the wood turns a little darker in color and becomes dull and porous looking like a piece of fine grained blotting paper. As the rot progresses, numerous checks or horizontal cracks appear. These do not appear to be due to shrinkage but rather to have been dissolved out by the action of the hyphae. They extend individually only through a single layer of springwood, but in the later stages of the decay, short vertical cracks connect the horizontal and a complete network is formed which becomes completely filled with white mycelium. The wood at this stage splits very easily along the annual rings into concentric layers. On the inner side of these layers, the network of cracks filled with the white mycelium, shows up very conspicuously. At the same time or a little before, numerous black dots make.their appearance at irregular intervals throughout the decayed wood. They increase in number and sometimes form lines as the wood goes into the later stages of decay. They are more or less distinct in outline and are harder than the surrounding wood. They vary slightly in color but are usually so dark a brown that they appear black to the unaided eye. They are usually not more than a few millimeters in any dimension.

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[2] Polyporaceae Middle-Western U. S., L. O. Overholts. Washington University Studies, Vol. III, part I, No. 1. 1915.

The fungus is primarily a cellulose destroyer but soon attacks lignified structures also. The mycelium attacks first the medullary rays and partially destroys them. All free cellulose is absorbed at this stage since various tests for it gave negative results in the rays and traceids alike. The fungus now fills the ray cavities with a mass of tangled hyphae, frequently containing some of the thick elements found in the context of the pileus. At this same time it attacks the tracheids, starting at the bordered pits. These are eaten out until only irregularly shaped holes remain. The hyphae may now pass easily from one tracheid to the next by simply dissolving a hole in the wall. The hyphae branch freely throughout the wood and seldom pass from one ray to the next without doing so. Clamp connections are very abundant and seem to be the rule. Occasionally they occur at branches and cause the mycelium to appear swollen at the joints, which is not really the case. As a rule the hyphae are hyaline, slender, 4–8 μ in diameter, except in the rays mentioned above, and are filled with many small oil globules. However where the black spots appear, the hyphae are often thicker and shorter jointed and have a brown color. The brown color is due to the presence of small brown globules possibly of some substance from the wood, toxic to the fungus and isolated in these spots.

Chemical tests used to detect the presence of cellulose:

1. Iodine in KI solution followed by treatment with weak sulfuric acid (1–3) colors cellulose blue;
2. Chloriodide of zinc colors cellulose blue;
3. Iodine in alcohol colors cellulose faintly yellow.

Of lignin:

1. Iodine in alcohol colors lignin deep yellow;
2. Phloroglucin followed by hydrochloric acid colors lignin bright carmine red wherever present;
3. Carbolic acid and hydrochloric acid followed by exposure to daylight for an hour color lignin green.

The use of these tests showed the removal of the cellulose from the rays in the early stages. Soon afterward, however, the tracheids in the spring wood were attacked and the middle lamella laid bare, so that a test at just the right stage indicated a small amount of free cellulose present here. As the rot progressed, tests for cellulose failed altogether, and those for lignin grew fainter. However, phloroglucin and hydrochloric acid indicated a small amount present in the most rotten wood. This action of the fungus indicates that it secretes both lignin and cellulose dissolving enzymes during its development.

In some respects the rot is very similar to that caused by *P. borealis* in the same host. As that seems to have the checks in the spring wood also, the presence of the before mentioned black spots and lines in the case of the decay caused by *P. tsugae* is the chief means of identification when sporophores of the fungus are not present.

The rot can usually be detected, in the older stages at least, by the presence of the sporophores with their very glossy red surface and the white context from the crust to the tubes. The rot in the wood is characterized by its being primarily a sap rot (though it finally rots the heart-wood also) producing a porous condition, with numerous white checks in the spring-wood and blacks spots scattered through the rotted area.

New Brunswick, N. J.